Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/22**

Paper 22 **March 2019**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the March 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

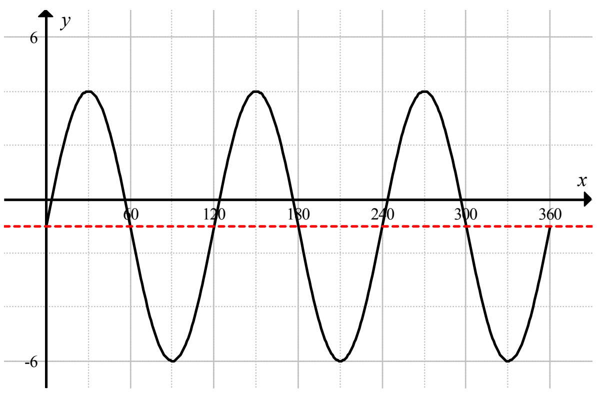
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(i)	1 081 575	**B1**	
1(ii)	40 320	**B1**	
1(iii)	2730	**B1**	
2(i)	$\frac{\mathrm{d}}{\mathrm{d}x}(\ln x)=\frac{1}{x}$, $\frac{\mathrm{d}}{\mathrm{d}x}(\mathrm{e}^x)=\mathrm{e}^x$ soi	**B2**	**B1** for each
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{e}^x\times \textit{their}\,\frac{1}{x}-(\ln x)\times \textit{their}\,\mathrm{e}^x}{(\mathrm{e}^x)^2}$	**M1**	
	correct completion to given answer, $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1-x\ln x}{x\mathrm{e}^x}$	**A1**	
2(ii)	$\delta y=\left(\frac{1-2\ln 2}{2\mathrm{e}^2}\right)\times h$ soi	**M1**	
	–0.0261[…]h isw	**A1**	
3(i)	Fully correct curve 	**B3**	**B1** for correct shape for sine with y-intercept at -1 **B1** for curve with period 120° **B1** for curve with amplitude 5 Maximum of 2 marks if not fully correct.
3(ii)	$a=-1 \quad b=5 \quad c=3$	**B2**	**B1** for any 2 correct
4(a)	Expands, rearranges to form a 3-term quadratic on one side $4x^2+x-3[*0]$	**M1**	
	Critical values $\frac{3}{4}$ and -1	**A1**	
	$-1\leqslant x\leqslant\frac{3}{4}$ final answer	**A1**	**FT** *their* critical values

Question	Answer	Marks	Partial Marks
4(b)	$k^2 - 4\left(\frac{1}{4}\right)\left(k^2 + 1\right)$	M1	
	-1	A1	
	discriminant independent of k and negative oe	A1	**FT** *their* -1
5	$[m_{AB} =]\ \frac{2+4}{3-7}$ oe or $-\frac{3}{2}$ soi	M1	
	$[m_{CD} =]\ their\frac{2}{3}$ oe, soi	M1	
	$their\frac{2}{3} = \frac{3+3}{k-2}$ oe or $3 + 3 = their\frac{2}{3}(x-2)$ oe	M1	
	$k = 11$ nfww	A1	
	$\left(\frac{(their11)+2}{2}, \frac{3+-3}{2}\right)$ oe	M1	
	$y = -\frac{3}{2}(x - 6.5)$ oe isw	A1	**FT** *their* m_{AB} and (*their* 6.5, 0)
6(i)	Takes logs, to any base, of both sides and applies the addition/multiplication law for logs $\ln y = \ln(Ab^x) \Rightarrow \ln y = \ln A + \ln b^x$	M1	
	$\Rightarrow \ln y = \ln A + x\ln b$	A1	
6(ii)	$\ln y = 1.4x + 2.2$ oe or $\ln y = x\ln 4 + \ln 9$ oe	B2	**B1** for either $m = 1.4$ or $\ln b = 1.4$ or $c =$ 2.2 or $\ln A = 2.2$
	$[A = e^{their2.2} =]\,9$ and $[b = e^{their1.4} =]\,4$	B2	**FT** *their* 2.2 and *their* 1.4 **B1 FT** for $A = e^{their2.2}$ or $b = e^{their1.4}$ or correct FT decimal rounded to more than 1 sf
6(iii)	$\ln y = 6$ or $y = their9(their4^{2.7})$ or $y = e^{their2.2}(e^{their1.4\times2.7})$ or $\ln y = their1.4(2.7) + their2.2$ or $\ln y = (2.7)\ln(their4) + \ln(their9)$	M1	
	awrt 400 correct to 1 sf	A1	

Question	Answer	Marks	Partial Marks
7(i)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\sqrt{x^2+1}\right)=\frac{1}{2}\left(x^2+1\right)^{-\frac{1}{2}}\times 2x$	B2	**B1** for $\frac{\mathrm{d}}{\mathrm{d}x}\left(\sqrt{x^2+1}\right)=kx\left(x^2+1\right)^{-\frac{1}{2}}$ where $k \neq 1$
	$\sqrt{x^2+1}$ $+x\times \mathit{their}\left(\frac{1}{2}\left(x^2+1\right)^{-\frac{1}{2}}\times 2x\right)$	M1	
	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\frac{2x^2+1}{\left(x^2+1\right)^{\frac{1}{2}}}$ or $a=2, b=1, p=\frac{1}{2}$ nfww	A1	
7(ii)	Complete argument e.g. For stationary points $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ and when a and b are positive, ax^2+b cannot be 0 or $2x^2$ cannot be -1	B2	**FT** *their* positive a and b **B1 FT** for a partially correct argument e.g. Because $\frac{\mathrm{d}y}{\mathrm{d}x}$ cannot be 0.
8(i)	$6\mathbf{i}-4\mathbf{j}-(2\mathbf{i}+12\mathbf{j})$ oe	M1	
	$4\mathbf{i}-16\mathbf{j}$ oe, isw	A1	
8(ii)	$\left[\overrightarrow{OC}=\right]\overrightarrow{OA}+\frac{1}{4}\overrightarrow{AB}$ oe or $\left[\overrightarrow{OC}=\right]\overrightarrow{OB}-\frac{3}{4}\overrightarrow{AB}$ oe or $\left[\overrightarrow{OC}=\right]\frac{1}{4}\overrightarrow{OB}+\frac{3}{4}\overrightarrow{OA}$ oe or $3(x-2)=6-x$ and $3(y-12)=-4-y$	M1	
	$3\mathbf{i}+8\mathbf{j}$ oe	A1	
	$\left\lvert\overrightarrow{OC}\right\rvert=\sqrt{\mathit{their}3^2+\mathit{their}8^2}$	M1	
	$\mathit{their}\frac{3\mathbf{i}+8\mathbf{j}}{\sqrt{73}}$	A1	**FT** *their* $3\mathbf{i}+8\mathbf{j}$ and *their* $\sqrt{73}$
8(iii)	$-\frac{\lambda}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ oe, isw	B2	**B1** for $\frac{\lambda}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ seen or $\overrightarrow{OD}=\frac{1}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ oe

Question	Answer	Marks	Partial Marks
9(a)(i)	Valid explanation e.g. Each x is mapped to a unique value of y [and so g is a function] but the inverse does not exist because it is many to one oe	**B2**	**B1** for either each x is mapped to a unique value of y oe or for inverse does not exist because it is many to one oe
9(a)(ii)	$\left[g^2(x)=\right]\ \ 6(6x^4+5)^4+5$ isw for all real x	**B2**	**B1** for $\left[g^2(x)=\right]\ \ 6(6x^4+5)^4+5$ isw **B1** for correct domain
9(a)(iii)	$[k=]\ 0$	**B1**	
9(a)(iv)	$x^4=\frac{y-5}{6}$ soi	**M1**	or $y^4=\frac{x-5}{6}$
	$x=\pm\sqrt[4]{\frac{y-5}{6}}$	**A1**	or $y=\pm\sqrt[4]{\frac{x-5}{6}}$
	$h^{-1}(x)=-\sqrt[4]{\frac{x-5}{6}}$	**A1**	If **M1 A0 A0**, allow **SC1** for an answer of $h^{-1}(x)=\sqrt[4]{\frac{x-5}{6}}$ or $y=\sqrt[4]{\frac{x-5}{6}}$
9(b)(i)	$p>2$	**B1**	
9(b)(ii)	For p: Correct exponential shape tending to $y=2$ passing through (0, 5)	**B2**	**B1** for each
	For the inverse function: Approximate reflection of p in the dotted line passing through (*their* 5, 0)	**B1**	
9(b)(iii)	Valid explanation e.g. The graphs do not intersect and so there are no solutions oe	**B1**	
10(i)	Eliminates x or y e.g. $3x+3=x+5\sqrt{x}+1$ or $3+3u^2=u^2+5u+1$	**M1**	
	Rearranges to a 3-term quadratic e.g. $0=2x-5\sqrt{x}+2$ or $0=2u^2-5u+2$	**A1**	
	Factorises or solves $0=2x-5\sqrt{x}+2$ oe or $0=2u^2-5u+2$ oe	**M1**	
	$\sqrt{x}=0.5$, $\sqrt{x}=2$ or $u=0.5$, $u=2$	**A1**	

Question	Answer	Marks	Partial Marks
	$A(0.25, 3.75)$ $B(4, 15)$ oe	**A2**	**A1** for each or for $x = 0.25$ and $x = 4$

Question	Answer	Marks	Partial Marks
10(ii)	**Method 1: Finding the area of the trapezium and subtracting**		
	Valid method to find the area of the trapezium soi	**M1**	
	$\frac{1125}{32}$ or $35\frac{5}{32}$ or 35.2 or 35.15625 rot to 4 or more figs, soi	**A1**	
	Attempts to integrate $\int_{their\,0.25}^{their\,4}(x+5\sqrt{x}+1)\,\mathrm{d}x\,[-their35.2]$	**M1**	
	$\left[\frac{x^2}{2}+\frac{5x^{\frac{3}{2}}}{3/2}+x\right]_{their\,0.25}^{their\,4}$ $[-their35.2]$ oe	**A1**	
	F(*their* 4) – F(*their* 0.25) [–*their*35.2]	**M1**	
	$\frac{45}{16}$ or $2\frac{13}{16}$ or 2.8125 isw or 2.81, or 2.812	**A1**	
	Method 2: Finding the difference of two integrals		
	Attempts to integrate $\int_{their\,0.25}^{their\,4}(x+5\sqrt{x}+1-(3+3x))\,\mathrm{d}x$ or $\int_{their\,0.25}^{their\,4}(-2x+5\sqrt{x}-2)\,\mathrm{d}x$ oe	**M2**	**M1** for an attempt to form the difference with at most one error and attempts to integrate
	$\left[their\left(\frac{-2x^2}{2}+\frac{5x^{\frac{3}{2}}}{3/2}-2x\right)\right]_{their\,0.25}^{their\,4}$ oe	**A1**	**FT** dep on at least M1 already awarded; must be at least 3 terms and, if FT, must be of equivalent difficulty
	F(*their* 4) – F(*their* 0.25)	**M1**	
	$\frac{45}{16}$ or $2\frac{13}{16}$ or 2.81, 2.812 or 2.8125	**A2**	

Question	Answer	Marks	Partial Marks
11(a)	$\frac{x^2(x^6+1)}{x^6}=x^2+\frac{1}{x^4}$ soi	**B1**	
	$\frac{x^3}{3}+\frac{x^{-3}}{-3}+c$ oe, isw	**B2**	**B1** for any two out of three terms correct
11(b)(i)	$k\sin(4\theta-5)$ where $k>0$ or $k=-\frac{1}{4}$	**M1**	
	$\frac{\sin(4\theta-5)}{4}\ (+c)$	**A1**	
11(b)(ii)	$\frac{\sin(4(2)-5)}{4}-\frac{\sin(4(1.25)-5)}{4}$ or $\frac{\sin(3)}{4}-\frac{\sin(0)}{4}$	**M1**	**FT** *their* **(b)(i)**, **dep** on **M1** awarded in **(b)(i)**
	0.0353 or 0.03528[…] oe, cao	**A1**	